

## **Evaluation of Galvanic Vestibular Stimulation System**

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Microgravity exposure results in an adaptive central reinterpretation of information from multiple sensory sources to produce a sensorimotor state appropriate for motor actions in this unique environment, but this new adaptive state is no longer appropriate for the 1-g gravitational environment on Earth. During these gravitational transitions, astronauts experience deficits in both perceptual and motor functions including impaired postural control, disruption in spatial orientation, impaired control of locomotion that include alterations in muscle activation variability, modified lower limb kinematics, alterations in head-trunk coordination as well as reduced dynamic visual acuity. Post-flight changes in postural and locomotor control might have adverse consequences if a rapid egress was required following a long-duration mission, where support personnel may not be available to aid crewmembers. The act of emergency egress includes, but is not limited to standing, walking, climbing a ladder, jumping down, monitoring displays, actuating discrete controls, operating auxiliary equipment, and communicating with Mission Control and recovery teams while maintaining spatial orientation, mobility and postural stability in order to escape safely. The average time to recover impaired postural control and functional mobility to preflight levels of performance has been shown to be approximately two weeks after long-duration spaceflight. The postflight alterations are due in part to central reinterpretation of vestibular information caused by exposure to microgravity. In this study we will use a commonly used technique of transcutaneous electrical stimulation applied across the vestibular end organs (galvanic vestibular stimulation, GVS) to disrupt vestibular function as a simulation of post-flight disturbances.

The goal of this project is an engineering human-in-the-loop evaluation of a device that can degrade performance of functional tasks (e.g. to maintain upright balance) similar to what astronauts experience during transitions to new gravitational environments. Stochastic electrical stimulation can be applied to the vestibular system through electrodes placed over the mastoid process behind the ears in the binaural configuration resulting in stimulation in the mediolateral (side-to-side) plane. An additional electrode can be placed over the bony landmark of the tip of the c7 spinous process for the double monaural configuration, which will cause stimulation in the anteroposterior (forward-backward) plane. A portable constant current bipolar stimulator with subject isolation was designed and built to deliver the stimulus. The unit is powered using a 3.7 V battery pack and designed to produce currents up to 5 mA. The stimulator, controlled by a Raspberry Pi 3 computer, offers several stimulus signal generation options including a standalone mode, which uses onboard signal files stored on the flash memory card. Stochastic stimulation signals will be generated in 0-30 Hz frequency bandwidth. Stimulation amplitude can be increased incrementally to a maximum amplitude of 5.0 mA (e.g., 0, 0.5, 1.0, 1.5, 2.0, 2.5, 3.0, 3.5, 4.0, 4.5, 5.0 mA). In control trials, subjects will be experiencing vestibular stimulation with 0-mA current applied through the electrodes. The system will be evaluated at various levels of stimulation and in both the binaural and double monaural electrode configurations. One of the objectives is to identify stimulation levels producing effects most comparable to the post-flight disturbances. This is a pilot study that will set the stage for a larger, more comprehensive study that will investigate wider aspects of post-flight sensorimotor dysfunction and set sensorimotor standards for crew health.